

iii. Aircraft Based Russian Wheat Aphid Remote Sensing

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Introduction. The Russian wheat aphid is a serious threat to small grains including wheat and barley. Early detection of the pest is essential for management strategies including pesticide application. Due to environmental concerns and the small profit margin associated with small grain production, the decision to use an insecticide during a pest outbreak is crucial to farmers (Royer, Giles and Elliott 1998). With timely and precise detection of Russian wheat aphid presence, pest control measures could be carried out in a way that reduces economic losses and environmental impacts (Yang et al., in press). The purpose of this project is to examine multi-spectral remote sensing for its utility in detecting Russian wheat aphid infestations in wheat fields.

Background. The Russian wheat aphid is not native to the United States. The first US specimen was found in March of 1986 in the Texas panhandle. The Russian wheat aphid is small ($< 1/10$ inch) and greenish to grayish green. The shape of the insect is distinctive. It is more elongate than other aphids and the antennae and cornicles are short. Population explosions of Russian wheat aphids cause a speedy progression of crop damage in infested fields. Under heavy infestations, severe yield reductions of up to 100% are possible, and grain test weights can be reduced to only 20 percent of normal (Hein et al 1998).

Objectives.

- Use remote sensing to detect the presence of Russian Wheat Aphids in field plots.
- Examine the relationship of mean Normalized Difference Vegetation Index (NDVI) and density of aphids in each test plot.
- Determine if remote sensing is capable of differentiating stresses caused by drought and the Russian Wheat Aphid.

Study Area. The study area was located in southeastern Colorado in Baca and Prowers Counties (see figure on left below). One wheat field was examined in each county. It is important to note that these wheat fields were already under some drought stress in addition to the Russian wheat aphid presence (see figure below to right). Each field had 24 3x3 meter plots. White towels were laid down in the field to locate the plots in the image. They appear as small white dots in the image. Twelve plots were located in highly infested parts of each field, and 12 plots were located in less infested parts. Aphid density was determined for each plot. Immediately after sampling the plots for Russian wheat aphids, remote sensing imagery was obtained using a multi-spectral imaging system called the SSTCRIS. With these data, we could compare aphid density for each plot with reflectance intensity in remote sensing imagery for the plot.



Study Area (Wheat Fields)

- Grower #51
- Grower #53



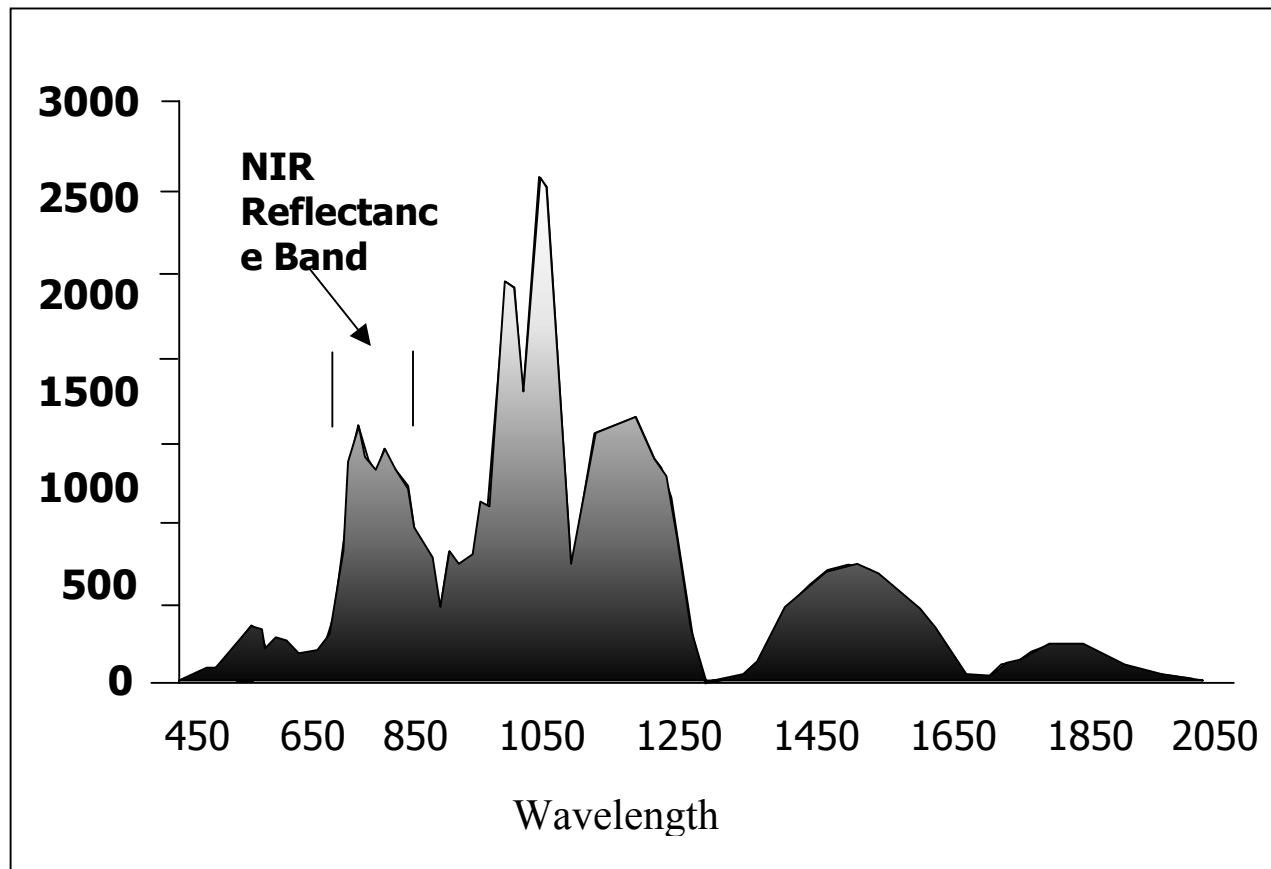
False color composite of study area in the Gower #53 field demarcated by four tarps.

Plant Stress and NDVI. When Russian wheat aphids feed on a plant and the plant becomes damaged, the plant is stressed. Plant stress is the deviation from the optimal conditions for growth, and could cause harmful effects when the threshold of the plants' ability to compensate is reached (Larcher 1995). Plant stress can occur due to water deficiency, nitrogen deficiency, insect infestation, disease, and other causes.

The Normalized Difference Vegetation Index is a commonly used and effective way to detect plant stress. The near-infrared band and red band of remotely sensed images are used to calculate NDVI.

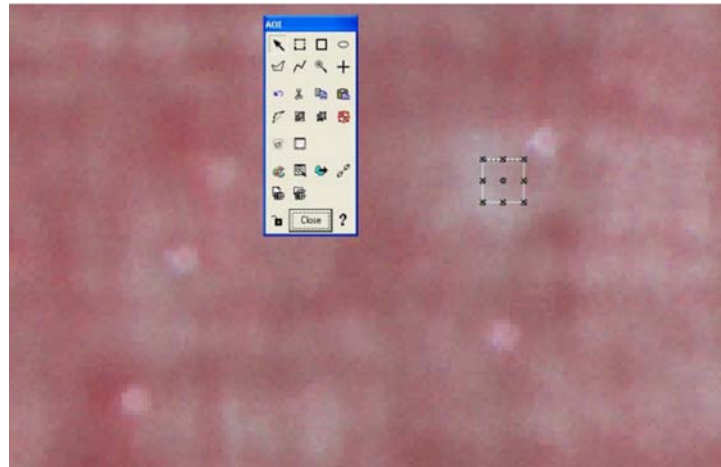
$$NDVI = (NIR - red) / (NIR + red)$$

Plants under stress show a decrease in reflectance in the NIR spectrum and reduced absorption of light in the photosynthetic spectrum (Shibayama et al. 1993). Due to these properties, reflectance can be used to assess stress levels in plants (Fernandez et al. 1994) (see figure below).



Methods

- Re-project images to the UTM Nad 83 zone 13 north coordinate system using ERDAS Imagine 8.6 software. Georeference the aerial remotely sensed images to the point layer of tarp and towel locations using ERDAS Imagine 8.6.
- Use towel point layer to identify correct locations of plot corners.
- In ERDAS, create AOI's (areas of interest) of 2x2 meter plot area one meter SW of the towels used to mark the NE plot corner. This was done for all 48 plot locations in the Grower #51 and Grower #53 fields (see figure below).
- Create subsets for each plot from AOI areas in ERDAS.
- Convert all pixels within each subset to a spreadsheet format from which to calculate mean NDVI for each plot.



Results and Conclusions. We have shown that multi-spectral remotely sensed data was sensitive to variation in the density of Russian wheat aphids in production wheat fields. Both fields studied showed lower NDVI values for highly infested plots than for less infested plots (see figures on next page). Despite the fact that the fields were drought stressed, Russian wheat aphid presence could still be identified using the NDVI values for each plot. The Grower #51 field showed a high coefficient of determination (.69) between Russian wheat aphid density and NDVI. Lower NDVIs were found in plots with higher Russian wheat aphid densities indicating that the additional stress caused by Russian wheat aphids in the drought stressed field was evident in the imagery. The Grower #53 field was not as heavily infested with Russian wheat aphids and that may explain the lower coefficient of determination (.44). Results of this study were encouraging, and indicate that further research is warranted to determine whether multi-spectral remote sensing can be used for detecting Russian wheat aphid infested fields in operational pest management programs for the pest.

References

- Fernandez, S., Vidal, D., Simon, E., and Sole-Sugarnes, L. 1994. "Radiometric characteristic of *Triticum aestivum* cv. Astral under water and nitrogen stress." *International Journal of Remote Sensing*. 15: 1867-1884.
- Hein, G., Baxendale, F., Campbell, J., Hagen, A., Kalisch, J. *Russian Wheat Aphid*. Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln Cooperative Extension. 9 June 2004. <http://ianrpubs.unl.edu/insects/g936.htm>
- Larcher, W. *Physiological Plant Ecology, 3rd Edition*. Berlin,: Springer-Verlag, 1995.
- Peairs, F.B. *Aphids in Small Grains*. Colorado State University Cooperative Extension. 19 July 2004. <http://www.ext.colostate.edu/pubs/insect/05568.html>
- Royer, T., Giles, K., Elliott, N. *Insects and Mites in Small Grains*. Oklahoma Cooperative Extension Services. 20 July 2004. <http://pearl.agcomm.okstate.edu/insects/crop/f7176.htm>
- Shibayama, M., Takahashi, S., Morinaga, S., Akiyama, T. 1993. "Canopy Water Deficit Detection in Paddy Rice Using a High Resolution Field Spectroradiometer." *Remote Sensing Environ*. 45: 117-126.
- Yang, Z., Rao, M., Kindler, S., Elliott, N. 2004. Remote Sensing to Detect Plant Stress, with Particular Reference to Stress Caused by the Greenbug: A Review. *Southwestern Entomol*. 29: 227-236.

